FIELD AND LABORATORY
STANDARD OPERATION PROCEDURES
And
QUALITY ASSURANCE PLAN

for conducting

Sediment and Nutrient Investigations

Note: This SOP was developed specifically for application to a total maximum daily load (TMDL) project and should be modified to meet the goal, objectives and data quality objectives specific to a project management plan in per Federal Acts, CFRs and USACE policy and guidance:

1) Federal Water Pollution Control Act Amendment of 1961 (P.L. 87-88) - (33 U.S.C. 1252) Clean Water Act (33 U.S.C. 1251 et seq.)
2) Code of Federal Regulations Title 33 Part 222.5 - Navigation and Navigable Waters
3) Division directive establishing District WQ management programs for operating projects in H&H (DIVR 1110-2-205)
4) Water Quality and Environmental Management for Corps Civil Works Projects (ER 1110-2-8154)
5) Reservoir Water Quality Analysis (EM 1110-2-1201)
6) Hydrologic Analysis of Watershed Runoff (EM 11110-2-1464)
7) Low Level Discharge Facilities for Drawdown of Impoundments (EM 1110-2-50)
8) Quality Assurance of Laboratory Testing Procedures (EM 1110-1-261)

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1.0 Introduction

A total maximum daily loading (TMDL) is the sum of pollutants (loads) from both point and non-point sources plus a margin of safety (40 CFR 130.2 and CWA §303(d)(1)(c)). Components of TMDL development include: (1) problem identification; (2) develop numeric targets; (3) identify sources and sinks of the targeted pollutant(s); (4) link targets and sources; (5) allocate loads or controls among sources; (6) develop monitoring and review plan/schedule; (7) develop implementation plan. Developing, testing, and implementing field and laboratory standard operation procedures and quality control plans are essential in each of the above components of TMDL development. The objective of this SOP is to provide guidance (field and laboratory procedures) on data acquisition, laboratory analyses, data reduction and management, and data quality.

2.0 Field Procedures (Dynamic)

2.1 Bedload Sampling

General Discussion. Bedload is defined as sediment that is transported along the streambed by sliding, rolling, or bouncing (Hubbell, 1964, Leopold et al., 1964, and Emmett, 1980a). Bedload samplers are designed to estimate mobilized bedload which is conveyed usually within 3 inches of the streambed. Obtaining bedload measurements representative of the actual bedload is problematic. Field technicians should recognize and take steps to minimize the following potential error associated with bedload sampling:

- If the streambed is irregular, the sampler could be posed unevenly on the streambed and a representative sample would not be collected;
- When deployed on the streambed, the sampler may disturb the existing stream flow and bed material; and
- There is a time and space (in cross-section and planform) variation in bedload transport rate and stream velocity, consequently, the sample collected at a given point may not be representative of the actual mean sediment transport rate.

Apparatus. Bedload samplers of the Helley-Smith design or an equivalent will be used to sample sediment being transported along the streambed. Both hand held and suspended models are acceptable with either 3-inch or 6-inch orifice. The preferred orifice size will depend upon the anticipated channel grain size. For example, bed material found within the Piedmont and Coastal Plain physiographies are fine-grained, thus the 3-inch orifice size may be adequate. However, a comparative study between different sized samplers should be conducted before proceeding with the 3-inch sampler *in lieu* of the 6-inch sampler. A sampler bag constructed of Nitex™ nylon or equivalent is attached to the bedload sampler. For most applications, the sampler bag should have a 0.25 mm mesh size. Depending on stream conditions (i.e., stream depth and velocity), the bedload sampler is outfitted with a 6 to 8-foot pipe handle for wading or is lowered off the culvert or bridge from a cable and winch system.

Procedure. In order to collect representative bedload samples, reduction in the error associated with sample collection identified above is important. The step-wise field procedure for bedload deployment is meant for general guidance and not a replacement for judgment in identifying station locations that reduce or eliminate error associated with bedload collection. Selection of sampling locations requires evaluation of local conditions. The following criteria should be utilized to identify representative stations:

- The stream should be relatively free of obstructions including large boulders, center bars, detritus and debris, and standing vegetation;
- The stream should have relatively even velocity in cross-section (laminar flow);
- Upstream of the station, the stream should be free of recent activities (e.g., beaver dams, man-made structures) that impede the "natural" conveyance of sediment; and
- In general, the station should not be located immediately downstream of a sediment source that does not have an adequate mixing zone resulting in an uneven distribution of sediment at the sample collection cross-section.

Once an appropriate cross section is established, the cross section should be cleared of large boulders and debris and a relatively flat surface maintained throughout sampling. The width of the wetted surface of the stream should be determined by locating zero tape on the left-edge-of-water (LEW) and measuring across to the REW. It may be required to repeat this step during storm event sampling, given the temporal variation in stage and wetted surface width. However, once cross sectional spacing for bedload and suspended load sampling is established during baseflow conditions, it is at the discretion of the project leader if horizontal spacing is to be re-established. In general, the more intervals sampled per traverse, the greater the probability that the composited sample is representative of the true bedload discharge. However, the number of points sampled per traverse must be weighed against the allowable time at each station during a storm event. In general for stream widths less than 100 feet, the bedload sampler should be deployed at five (5) pre-determined, equally-spaced points per traverse for 2 minutes. Two traverses are recommended for a total of 20 minutes of bedload sampling per station. The composited sample is concentrated into one corner of the sampler bag and decanted into 1-liter, wide-mouth Nalgene™ jar or equivalent. The samples are preserved at 4°C and transported to the laboratory for analysis.

2.2 Integrated Water Column Sampling

General Discussion. The premise behind integrated water column sampling is to composite the vertical water column resulting in a sample that is representative of the relative quality and quantity of suspended sediment throughout the water column at a point in space and time. The suspended sediment sampler (e.g., DH-59 or equivalent) should be capable of isokinetic sampling (i.e., the nozzle orientation and orifice are designed to simulate the flow and sediment transport rate of the stream). Field technicians should recognize and take steps to minimize the following potential error associated with suspended sediment sampling:

- The stream may not be completely mixed in cross section;
- When deploying the suspended sediment sampler, the sampler may cause re-suspension of bed material; and
- There is a time and space (in cross-section and planform) variation in suspended sediment transport rate and stream velocity, consequently, the sample collected at a given point may not be representative of the actual mean sediment transport rate.

Procedure. Sampling stations should be established taking into consideration the criteria identified above in ***Bedload Sampling***. Field technicians should be familiar with instructions provided by the manufacturer on use of suspended-sediment samplers. Instructions for sampling with depth-integrating suspended-sediment sampler US DH-59 are included in a separate SOP. In general, the container (glass milk bottle) should not be completed filled during vertical integration of the water column. If the container is completed filled, it is not representative (both quality and quantity) of the suspended sediment throughout the water column and should be discarded. The optimal volume of sample collected should be between 375 and 440 ml. Field technicians should develop the skills required to collect a fully integrated sample given variation in local conditions (e.g., water depth, velocity).

Once an appropriate cross section is established, deploy the DH-59 at evenly-spaced points across the stream cross-section. It is at the discretion of the project leader to determine the number of sample points required. In general, in streams less than 50 feet wide that are well mixed, two evenly-spaced sample points are adequate. Larger stream widths may require 3 or 4 sample points. The sample bottle should be filled according to manufacturer's specifications. Depended upon the required sample volume, the sample can be composited across sample points within the bottle or samples from each sample point can be decanted into a small mixing pail and addition samples collected until an adequate volume of sample is produced (e.g., for TSS only: 400 ml; for TSS plus nutrients: 1000 ml). While gently swirling the pail, fill a glass cubette, and measure turbidity using a LaMotte™ Model 2020we or equivalent. Decant the remainder of sample into a storemore for TSS/TDS analysis and 1-liter plastic nutrient bottle or ½-gal. milk jug for nutrients (if required). Preserve the TSS sample at 4°C and nutrients with 10% H_2SO_4 to pH < 2 and 4°C.

2.3 River Reach and Habitat Assessment

General Discussion. River reach assessment is required to characterize the stream and valley geomorphology and habitat condition of the watershed. The results can be used to ground-truth GIS landuse and stream planform mapping, establish candidate sites for long-term bank stability and backslope erosion projects, identify sediment sources and sinks including areas of accelerated erosion and deposition, measure hydraulic geometry for model input, and identify reference reaches for comparative studies.

Apparatus. Conventional surveying equipment will be used for the cross-sectional profiles, whereas laser technology will be used to measure the channel slopes, cross-sectional geometry (e.g., bankfull and channelfull widths and depths), and longitudinal planform. Percent canopy closure will be estimated with a densiometer or equivalent. A digital photographic record will be made of each assessed reach.

Procedure. The watershed will be segregated into river reaches based on river segments (e.g., every 0.5 river miles), stream or valley classification, land use, or an appropriate method to meet the project goals. River reach assessment forms will be modified as necessary during the early stages of field survey. In general, the river reach assessment will include channel planform (e.g., bar morphology), riparian vegetation, channel evolution model status, bank properties, and bank and backslope erosion processes. Overall geomorphic condition and aquatic habitat will be assessed with a stream reach inventory model (Pfankuch, 1975) and the habitat assessment form (Plafkin et al., 1989). In addition, channel equilibrium will be assessed using a channel evolution model - CEM (Schumm et al. 1984).

Stream cross-sectional surveys, longitudinal (planform) profiles, and Wentworth "pebble counts," will be conducted according to methods described by Harrelson (1994), Rosgen (1996), and Leopold (1994). Pebble counts will be collected using Wentworth size classes according to Wolman (1954). Particles smaller than 2mm will be either placed in a <2mm or "silt/clay" size class, or differentiated into specific sand-sized fractions (e.g., 0.125, 0.250, 0.500, 1.00 mm) with the aid of a waterproof "sand card." Whenever possible, representative habitats (e.g., riffles, pools, runs) will be sampled proportionally according to the attributes of the given reach (i.e., if 70% of the reach was riffle habitat, and 30% pool, then at least 70 particles would be measured from riffle habitat within the reach and at least 30 particles would be measured from the pool). Post-processing of survey data will include the following:

1. Cross-sectional and longitudinal survey data will be graphed with appropriate descriptors of channel features such as thalweg, bankfull, and channelfull;
2. Channel capacity will be calculated for model input;
3. Meander wavelength, belt width, radius of curvature, amplitude, and sinuosity will be calculated from the planview plot derived from the longitudinal survey;
4. Particle size distribution from pebble counts will be displayed graphically on a combined cumulative percent plot (logarithmic scale) and appropriate size classes will be calculated for each reach; and

5. The results will be recorded on the river reach assessment forms and in appropriate spreadsheets and databases.

2.4 Georeferencing / Location

Latitude and longitude of each sample station will be determined using a hand held global positioning satellite (GPS) unit and verified using an appropriate mapping tool and recorded.

2.5 Stream Discharge / Stage Relationships

Stream velocity, stage, and discharge measurements and calculations will follow the Draft EAB-SOP (Revision 4/99), Sections 20.4 and 20.5.

2.6 Water Column Physiochemistry

General Discussion. Both continuous and instantaneous monitoring of conventional, water quality parameters is an essential part of water quality surveys. Conventional water quality parameters include temperature, pH, specific conductivity, dissolved oxygen, turbidity, redox potential, and water level. In addition to direct application to state water quality standards, conventional water quality parameters can be used as surrogates and "red flags" in priority ranking and targeting watersheds and river reaches for intensive water quality surveys. For example, TSS can be regressed against turbidity.

Apparatus. Multiparameter water quality probes will be used for continuous (off-line) and instantaneous monitoring (YSI™ Model 6920 or equivalent). For continuous monitoring of stream stage, the probes should be equipped with dual or differential pressure transducers and vented to the atmosphere.

Procedure. Off-line multiparameter probes, which measure continuously conventional water quality parameters, are deployed at predetermined stations. Calibration and deployment will follow the Draft EAB-SOP (Revision 4/99) with the following exception: YSI™ Model 6920 off-line sondes will be air calibrated for dissolved oxygen. Installation will include: (1) securing the probe to an existing stationary structure or providing a support to ensure a fixed position throughout the sampling period; and (2) venting the probe above the anticipated stream depth during the storm event.

3.0 Field Procedures (Biological)

General Discussion. Health and condition of aquatic biota provides the most appropriate endpoint for identifying physiochemical impairment, status of beneficial uses, establishing success criteria of restoration and management plans, and long-term ambient monitoring of restoration including BMP's. Obviously, since most beneficial uses are related either directly or indirectly to the status of stream biology, biological surveys are essential for the development of sediment and nutrient TMDL protocols. Habitat assessment is defined as the evaluation of the quality of the structure of the surrounding habitat that influences the quality of the water resource and the condition of the resident aquatic community (Barbour and Stribling, 1994). Parameters evaluated during the assessment allow conclusions to be drawn regarding substrate, habitat diversity, channel alteration, sediment deposition, in-stream cover and canopy, channel morphology, and riparian and bank structure.

3.1 Macroinvertebrate Sampling

Rather than quarterly sampling, macroinvertebrates will be sampled in the winter quarter and in mid to late summer. The study will use the Rapid Bioassessment Protocol III (Plafkin et al. 1989) multihabitat approach. In this approach the survey crews will sample macroinvertebrates in all habitat types in an attempt to collect as many different organisms as possible. A sampling reach of 100 - 200 meters which is representative of habitat conditions of the stream will be selected. Generally, the sampling effort should encompass a minimum of one man-hour per station and include the following habitats:

- riffles - 3 kick net samples from faster current, 3 kicknet samples from slower current;
- leaf packs (CPOM) - collect several handfuls of coarse particulate organic matter (CPOM), preferably partially decomposed leaf litter equal to approximately four liters of sample;
- undercut banks - using a D-frame or an A-frame biological dip net, make 6 sweeps or "jabs" along the bank;
- woody debris - collect 5-6 pieces of woody debris (snags, limbs, submerged logs) and wash down in a sieve bucket or biological dip net; and
- pools - using a D-frame or A-frame biological dip, make 3 one-meter sweeps to a 2-3 cm. depth from the bottom of the pool habitat.

The samples will be preserved in the field and taken to the laboratory for processing. Organisms will be sorted in the laboratory under magnifying lamps, and identified to the genus level.

3.2 Macroinvertebrate Habitat Evaluation

The habitat assessment utilizes the procedure as described by Barbour and Stribling (1994). This method modifies the original habitat assessment approach contained in the Rapid Bioassessment Protocols (Plafkin et al. 1989). It includes additional assessment parameters for high gradient streams and a different parameter set for moderate to low gradient glide pool prevalent streams (velocities generally less than 1 ft/s). A numeric value will be assigned to each of the habitat parameters based on the observed condition at the time of biological sampling. The habitat score of the study stream is the sum of the scores for all the parameters. Photographs will be taken at each station in order to document habitat condition. As required to address habitat loss resulting from accelerated sedimentation, new biological matrices will be developed which are suitable endpoints specific to the type of impairment.

3.3 Fish Sampling

Sampling for fishes will take place only once annually - in mid to late summer. Fish community sampling will follow the RBP V procedure as outlined in Plafkin et al. (1989). RBP V is a rigorous approach that involves careful standardized field collection, species identification and enumeration, and community analyses using biological indices or quantification of the biomass and numbers of key species. The RBP V survey yields an objective, discreet measure of the health of the fish community. Sampling effort among stations will be standardized as much as possible and the collection method, site length (or area), and work hours expended will be comparable to allow comparisons of fish community status across stream-reaches and subwatershed. Major habitat types sampled at each site and the proportion of each habitat type sampled will be comparable. Sample processing and data recording and analyses will follow the procedures outlined in the RBP V methodology.

4.0 Field Procedures (Automated)

4.1 Stage/Discharge and Water Column Sampler

General Discussion. Stage-discharge relationships (rating curves) are important in establishing watershed response, loadings (e.g., tons sediment / year), and watershed scale modeling. Water column samplers are important for round-the-clock, stage-actuated sampling of TSS and nutrients on baseflow and stormflow events. In addition, establishing a correlation between the automated sampler and the integrated sampler (DH-59) is important for future hands-free operation and identifying surrogates to replace laborious, manual sampling.

Apparatus. Rain gages (tipping bucket) will been installed at locations representative of the spatial variation in precipitation. Stream stage will be monitored with a combination of equipment including conventional stage recorders with encoders, and continuous recording ultra-sonic, bubbler, and submerged probe flow meters. An ISCO Model 3700 automatic sampler will be installed at each station. As soon as state-of-the-art instrumentation is made available, the new equipment will be calibrated (if required), deployed, and tested against standard, proven equipment. Expected upgrades include ISCO model 6700 automatic samplers with liquid level actuators, Stevens Axsys Systems for stage measurements, and ISCO Model 4200 series flow meters for stage measurements and cellular communications.

Procedure. In an effort to reduce the time required to reset the equipment during dry weather and unpredictable, unevenly distributed rain events, alternative methods will be explored to activate the automatic samplers based on stream stage or other conventional parameters (e.g., temperature, specific conductivity, turbidity). The stage equipment and flow meters will be set to record and store stage measurements at 15-minute intervals.

These data will be downloaded on a monthly basis into a spreadsheet format for inclusion with sampling and rainfall data, and subsequent loading determinations. The automatic samplers will be set to activate automatically on a predetermined rise in stream stage. Cellular communications will be installed at specified stations to notify the field personnel upon activation of a sampling event. Once activated, the sampler will be programmed to collect individual samples at two-hour intervals over a duration of 48 hours. At the end of the sampling period, the field team will evaluate the stage-discharge data and collect a representative number of samples along the rise, peak, and fall of the hydrograph. An estimated maximum of 7 samples will be collected at each station. However, the total number of samples may be less if the duration of the hydrograph is less than 48 hours. The sampling period may also be increased if the duration of the hydrograph is projected to exceed 48 hours.

5.0 Laboratory Procedures

5.1 Nutrients

Samples collected from the ISCO automated samplers and DH-59 (if appropriate) will be analyzed for nitrate + nitrite, total kjeldahl nitrogen, ammonia, and total phosphorus using standard USEPA methods.

5.2 Sediment

The bedload sample is sieved through a 2mm sieve and separated into two different size fractions. The size fractions follow two different analysis paths. The less than 2mm fraction is analyzed for particle size, and the greater than 2mm size is analyzed for carbon, nitrogen, sulfur content, and, as required, particle size analysis (wet sieve technique, separate SOP). Step-wise procedures for both size fractions follows:

Bedload Analysis For >2 MM Fraction
1. Separate the sample through a 2mm sieve.
2. Place the fraction caught by the sieve into a tared, clean, crucible.
3. The >2MM fraction will then be dried in a convection oven at 103-105°C for 24 hours. (Standard Methods 2540B).
4. The oven-dried sample will then be pulverized by a ball-mill grinder (e.g., SPEX™ 8000 or equivalent instrument) and placed in an air-tight container to be analyzed by an elemental analyzer (e.g. Leco™ or equivalent instrument) at a later date, or analyzed by the muffle furnace for loss on ignition (volatile solids determination Standard Methods 2540 E).
5. If particle size fractionation is required, see wet sieve technique.

Bedload Analysis For < 2MM Fraction
1. Separate the sample through a 2mm sieve;
2. Place the fraction that passes through the sieve into a benthic jar or other appropriate container;

3. If necessary, a dispersing agent (e.g., sodium metaphosphate) will be added to remove cementing agents;
4. Stir the sample for approximately 2-3 minutes or allow the sample to agitate overnight in a shaker;
5. Allow the sample to settle for approximately 14 hours (overnight) so the particles may settle out of suspension according to Stoke's Law;
6. Obtain an aliquot of the sample, from the benthic jar, using a pipette and stopper to capture the entire stratigraphic column of the sample, and introduce the aliquot into a laser particle analyzer (e.g., Coulter L.S. 200 ™ or equivalent instrument) for particle size analysis; and
7. The sample can then be processed further according to steps 3 and 4 of the >2MM fraction if the analysis is desired.

Total Suspended Solids Analysis
Laboratory analysis for TSS is conducted according to Standard Method 2540D.

6.0 Quality Control / Quality Assurance Plan

Appropriate accuracy and precision estimates for each method will be followed according to SOPs. At least 10% of the time, measurements, collections, and analyses will be conducted in duplicate to estimate laboratory and field precision for each variable estimated. In general, this sampling program is designed to meet the following requirements:

1. In order to improve consistency and reproducibility, field and laboratory personnel will be trained on sampling and analytical techniques and procedures;

2. Field and laboratory data will be statistically reduced taking into account the goals of the study and its certainties and uncertainties;

3. Field personnel will be knowledgeable of error associated with sampling techniques and given instruction on error reduction; and

4. Instructions of sampling collection, labeling, preservation, tracking, and transport are part of standard methods and this document.

Sampling and chain-of-custody procedures will be in accordance with the standard methods with the following exception: due to the remoteness of the sampling site locations, the distance between the sampling sites, and the unpredictability of the rainfall events, it is not feasible to maintain ice in the automatic samplers during the rain event to reduce the sample temperatures to 4°C. Every effort will be made to collect, preserve, and ice the samples as soon as possible after the rain event. The samples will be analyzed for TSS and nutrients. Turbidity measurements will be made in the field. The analyses for TSS will be conducted qualified Laboratory analysis should be conducted at laboratories with proper accreditation (e.g., NELA).

Blank Sample Needs. Blanks are defined as samples expected to have negligible or unmeasurable amounts of the substance of interest, in this case, TSS and nutrients. They are required to estimate the uncertainty due to random errors. Random errors can be estimated statistically. Since precision is estimated by the standard deviation of the random error, and the standard deviation is the square root of the variance, precision can be estimated by the summation of the variance. The following equation includes the various errors (variance) that may occur in sediment TMDL sampling:

$$S^2_T = S^2_a + S^2_t + S^2_s + S^2_{hw} + S^2_{hm} + S^2_p + S^2_c + S^2_m \quad (1)$$

Where
- T = total
- a = spatial
- t = temporal
- s = sampling
- h = transport and storage
- p = preparation
- c = chemical treatment
- m = measurement variances

In order to determine the uncertainty due to the random errors identified above, trip and container blanks will be used during every storm event. Blanks cannot be devised to address the first two variables (S^2_a and S^2_t) and the last variable (S^2_m). Blanks will be prepared to estimate incidental or accidental contamination of the sample during each storm sampling event in the following ways (listed according to identified variable):

1. ***Equipment Blank (S^2_s):*** Following stream sampling with the integrated sampler (DH-59), the sampler will be cleaned per SOP, lowered into a container of organic-free water, allow to fill per SOP, and decantered into the preparation blank;
2. ***Water Transport Blank (S^2_{hw}):*** One (1) trip blank will be cleaned, filled with organic-free water, capped, transported to the sample collection site, and maintained within coolers;
3. ***Matrix Transport Blank (S^2_{hm}):*** One (1) trip blank will be cleaned, filled with a standard reference material of known organic carbon content, capped, transported to the sample collection site, and maintained within coolers; and
4. ***Preservative Blank (S^2_c):*** The reagent blank will be deionized water processed with H_2SO_4 to pH < 2.

The above blanks will be transported to the field, returned to the laboratory, and processed through the same analytical procedure as "blind samples".

7.0 Information Management and Data Analysis

General Discussion. Information management is the comprehensive framework that facilitates the management and communication of data and information collected from sources through time in a form appropriated for users. This study will incorporate and evaluate information management. The information management program must provide for the effective collection, processing, storage, cataloging, retrieval, dissemination and reporting of all pertinent data and information through all stages of the project. All of these activities must be considered as part of any comprehensive information management effort. Therefore, the information management network must include extensive communication among project managers, logistics staff, QA/QC personnel, scientists and cooperating agencies.

Operational Specifications

The Information Management System (IMS) will consist of the following major components: project management; data and sample collection; processing and storage of indicator data; data access and transfer; data analysis and reporting; data documentation, access, and archival; geographical information system (GIS); and integration of data.

Project Management System

The project management component of the IMS requires frequent and accurate status reports about field collection and laboratory processing activities. This component has two major elements: (1) a communication system for rapidly transferring information between field crews, processing laboratories, and (2) sample tracking system for monitoring the status of sampling events, sample shipments, and status of analyses on a real-time basis.

Data and Sample Collection

Field data will be recorded on data sheets designed for the project. These data include direct field measurements, as well as site information (e.g., latitude, longitude, ecoregion, sample ID). The data will be verified as described in the QA section. Field data will be submitted to the IMS in established time frames, and in approved formats for entry into the IMS.

Sample numbers will be assigned to each sample collected to ensure that all samples in the plan are properly identified and tracked. These numbers will be assigned by the field sampling coordinator and entered into the IMS before the sampling event. Sample labels will be produced before the sampling event whenever possible.

Processing and Storage of Data

Quality assurance will be performed on all data received by the IMS. The data sets will be stored in data libraries. Following initial data processing, the data analyses will be performed and summary data bases produced. The IMS will maintain data and relevant analytical results in both raw and summarized form.

Data Access and Transfer

The computer network will be the primary means of access to data in the IMS. All data base design work and documentation, including the code libraries, data dictionary, standard operating procedures for data handling, and GIS standards and base coverage will be available over this network. Ultimately, the data reports, and findings of this project will be of interest to the states, to the scientific community, and to the general public.

Data Analysis and Reporting
Analyses will be done only on data that have passed QA protocols. Data exchange interfaces will be developed between IMS, GIS, and other tools for data analysis.

Data Documentation, Access, and Archival
Complete documentation of all data bases stored in the IMS are of paramount importance. A Data Set Index (DSI) will be the principal data information source and will include a catalogue listing all available data, modes of access, and quality of the data. A data library contained within the DSI will provide users with important information about the contents of each data set. A Central Data Dictionary will document information about the contents of each data set. A Central Data Dictionary will document information on all standards that have been developed for data sets. The standards will include field names, formats, documentation, acceptable ranges, and codes. A data base backup system will be developed for complete and rapid recovery of all information in the event of a data base failure.

Geographic Information System
A major requirement of IMS capabilities will be to create maps and perform geographically based analyses; therefore, the data generated for these projects will be geo-referenced. Spatial analyses will be accomplished using GIS Arc-Info. Standards will be developed for data accuracy, naming conventions, and documenting and archiving completed maps.

7.1 Quality Assurance/Quality Control for Information Management

An important QA issue associated with a large program size of that proposed for the TMDL Savannah River Basin is ensuring and maintaining the integrity of the large number of data values that will eventually be entered into the information management system (IMS). The scientific importance of this project requires the utmost confidence in the validity of the final database.

There are two general ways that data are corrupted: (1) incorrect information is entered; and (2) data are missing, incomplete, or nonretrievable. Examples of errors of the first type include typographical errors, incorrect species identification, and inaccurate instrument calibration. Although all errors cannot be completely eliminated through data management protocols, the potential for including incorrect information in the database can be greatly reduced. The second type of error is the omission of important information relating to legitimate data values. Such pieces of information, called data qualifiers, assist in correct interpretation of data values.

Quality assurance/quality control measures are aimed at preventing corruption of data when it is initially incorporated into the system, and maintaining the integrity of data and information after its incorporation. The following elements have implemented QA/QC measures to ensure data integrity for the study: Data collection; sample tracking; data entry; data verification; data validation; and data archiving and backup.

Field Data Collection

A systematic numbering system will be developed for unique identification of individual samples, sampling events, stations, shipments, equipment, and diskettes. Sample containers, and equipment will be re-labeled to eliminate confusion in the field. The re-labeling will reduce the number of incorrect or poorly affixed labels. Standard operating procedures will document the data entry procedures. Qualified persons will conduct manual verification before the data are entered into the system.

Sample Tracking

The tracking and handling of samples collected in the field will be critical for QA of the resulting data.

Data Entry/Verification

The data entry process will include an accuracy check in which data will be entered twice or a 100% visual inspection will be performed. The following examples show the types of checks that will be performed if manual entry is required:

1. Range checks on numeric data - Field and laboratory numeric data and taxonomic codes must be checked for acceptability using established ranges for constituent concentrations or values (e.g., pH~1-14).
2. Certain fields will contain coded information - When codes are used, they will be compared with codes established by the scientific personnel and information management to assure compliance.
3. Data that have been flagged will be reported - QA personnel will review this report and release data that have passed the QA check for addition to the database. All errors must be corrected before the data can be entered.

Data Validation

All discrepancies identified by the computer will be documented in hard copy. Data will not be transferred to the data base until all discrepancies have been resolved. A record of all additions will be kept in hard copy.

Archive and Backup

Data generated, processed, and incorporated will be stored and archived on redundant systems. This will ensure that if one system is destroyed or incapacitated, information management personnel will be able to reconstruct the data bases. Procedures will be developed to archive the data, monitor the process, and recover the data if necessary.

Backup copies of the data (all levels) and of the programs used for processing the data will be maintained. Backups of the entire system will be maintained off the site, using designated system backup procedures.

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